Comparative Dental Analysis

Sallis, Claire ; Manica, Scheila

Published in:
Dental Update

DOI:
10.12968/DENU.2021.48.2.148

Publication date:
2021

Mandibular ramus as a sex predictor in adult Jordanian Subjects

ABSTRACT

Human Identification is an important part of criminal investigation, and a way to express the respect of the legal rights of the dead. It can be performed by comparative analysis or by constructing the biological profile that involves sex estimation. Some metric studies of sexing the mandible explore linear and areal measurements; however, these measurements are not advisable using uncalibrated radiographs and, alternatively, ratios and angular measurements should be tested. The main aim of this study was to explore the sex discrimination of condylar angle, mandibular notch angle and the ratio between mandibular and condylar-coronoid areas by tracing uncalibrated OPGs of 50 Jordanian subjects (aged 21-45 years; 50% each sex). The second aim was to develop a regression model to predict sex using angular and ratio measurements from OPGs. ImageJ(2015) software was used to assess the images and the data was subjected to Binary Logistic Regression analysis using SPSS(22). Results showed that the condylar and mandibular notch angles were statistically significant predictors of sex whilst the areal ratio was not significant. A predictive model was developed combining the two significant predictors which was able to correctly classify 77.6% of our sample. An Excel calculator was derived from this model and validated using novel data. 10 different OPGs were assessed using the calculator and 80% of them were classified correctly. The conclusion is that condylar and mandibular notch angles have potential as sex predictors for adult Jordanian subjects and the analysis of the results can be automated by the sex calculator.

KEYWORDS: ~~Forensic Dentistry;~~ Forensic Anthropology; Human Identification; Sex Estimation; Sex Calculator; Ramus Measurements.

INTRODUCTION

Human identification has gained more importance in a world with increasing crime rate, great numbers of refugees who die before asylum is granted, and victims who are found in decomposed and charred states [1,2,3]. The significance of human identification is not only to assist the right of the dead to be named and buried in a marked grave, but also to aid criminal investigation and help the victim's relatives to know the background of the case [4]. Human identification by comparative dental analysis is carried out by comparing ante-mortem (AM) records with the post-mortem (PM) findings; When AM records are not available, reconstructive technique is performed by analyzing the available evidence to construct the biological profile: sex, age, stature and ancestry [5,2].

Sex estimation is considered as the fundamental step in profiling as most of the methods used for assessing age, ancestry and stature are sex specific [6]. All bones are found to have some sexual indicators with the skull considered the second most reliable skeletal element after the pelvis and can survive decomposition process [6,7,8]. The mandible has been explored for sex dimorphism morphologically and metrically as it is considered to be the strongest bone of the skull, being easily identified even fragmented with a degree of sexual dimorphism [2,6]. To overcome the subjectivity and experience-related errors of morphological sex estimation, the researchers sex the mandible morphometrically [2]. Moreover, they analyze the sexual dimorphism of the mandible on different radiographs such as lateral cephalograms (LC) or computed tomography (CT) mainly based on linear and areal measurements [9,10,11]. Also, many studies were conducted on Orthopantomograms (OPG) for their availability, broad coverage of the lower face components and short time processing [12,13,14,15]. However, most of these methodologies require calibrating the radiographs by measuring the magnification factor or using visible rulers on the radiograph film which is not always possible.. This can be overcome by testing angular and ratio measurements [2].

Jordan is an Arab country bordered with 4 countries, 3 of which are in conflict [16]. The need of experts in human identification in this country is growing, especially with increasing crime rate [17]. Beside the crimes, identification of natural disaster victims is one of the challenges Jordan is facing. In 2018, twenty-one people died in flash flood. Under the pressure of the government and the families, the forensic staff misidentified two bodies which were solved later by DNA [18].

Moreover, Jordan was named the largest refugee hosting country in the world [16]. This has affected the crime rate indirectly by attributing to the economic pressure which is one of the main causes of crimes [20,21].

This study aimed to investigate the validity of 3 unexplored measurements_for sex dimorphism by analyzing uncalibrated OPGs of Jordanian subjects. And, to build a regression model for sex prediction that can easily be used by forensic specialists. The measurements are the condylar angle, mandibular notch angle and the areal ratio between mandibular area from right to left condyles and condylar-coronoid area.

Material and methods

This cross-sectional study of the mandible was conducted on 50 OPGs of anonymized North Jordanian subjects (equally distributed by sex) aged from 21 to 45 years as seen in table 1. The OPGs were collected from archives of Isteshary Radiology Private radiology center, Irbid, Jordan. The OPGs were taken for routine dental diagnostic procedures. Due to the anonymity of the subjects and permission of the clinic, a formal ethical clearance was not requested.

Age Range	Sex		Total
	Female	Male	
21 – 25	5	5	10
26 - 30	5	5	10
31 - 35	5	5	10
36 – 40	5	5	10
41 – 45	5	5	10
Total	25	25	50

Table 1: Distribution of subjects by sex and age

The criteria of inclusion included (a) healthy adult individuals with a known age (minimum of 21 and maximum of 45), sex and nationality, (b) absence of pathological or developmental diseases or syndromes affecting the mandible, (c) absence of history of fractures in the mandible and (d) a good image quality allowing the assessment of the anatomical features.

For accuracy and reproducibility, six anatomical landmarks were traced for each OPG. The Reference points were (A) the most superior point on the head of the left condyle, (B) the deepest point in the left mandibular notch, (C) the most superior point on the head of the left coronoid, (D) Gonion: the most posterior inferior point on the mandibular angle (left side), (E) Gonion (right side) and (F) the most superior point on the head of the right condyle as shown on the OPG in Figure 1.

Figure 1: Six anatomical landmarks in the mandible traced on an OPG

ImageJ (2015) software was used to assess the images [22] by calculating two areal and two angular measurements.

The first area was a triangle formed from joining the most superior point on the head of the left condyle (A), Gonion (left side, D) and the most superior point on the head of the left coronoid (C) as seen in figure 2. In order to mark the Gonion (point D), The tangent of the outer surface of ramus and the tangent of the lower border of mandible were drawn (dashed lines, figure 2). After that, a straight horizontal line from the intersection point of the two lines was drawn to touch the mandible at “point D” as shown in Figure 2. The same steps were followed to trace right Gonion “point E”.

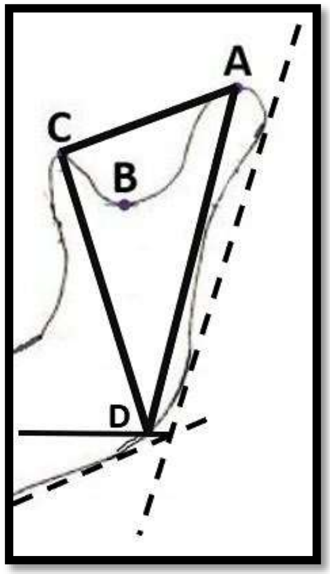

Figure 2: Tracing left Gonion (point D) and measuring the area of ADC triangle and condylar angle (angulation of AD line)

The second area was a polygon formed from connecting the most superior point on the head of the left condyle (A), Gonion (left side, D), gonion (right side, E) and the most superior point on the head of the right condyle (F) as seen in figure 3.

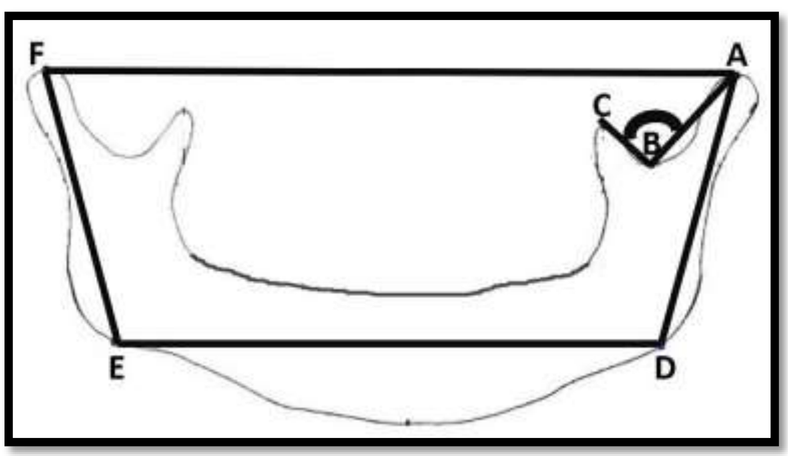

Figure 3: Measuring the mandibular notch angle (ABC angle) and the mandibular area (ADEF area)

The first angle was the mandibular notch angle (ABC) formed from connecting the most superior point on the head of the left condyle (A), the deepest point in the left mandibular notch (B) and the most superior point on the head of the left coronoid (C) as seen in figure 3.

The second angle was the condylar angle which is the angulation of AD line. It was calculated after connecting the most superior point on the head of the left condyle (A) and left Gonion (D) as seen in figure 2. The absolute value of the angle was considered.

Intra-Observer reliability test was carried out by the author on a random 20% of the sample (10 OPGs) after two weeks of interval. The same radiographs were assessed by another researcher for the Inter-Observer reliability test. The statistical analysis of the data included Intraclass Correlation Coefficient (ICC: 2, single measures, absolute agreement) reliability test and Binary Logistic Regression Using IBM SPSS (22).

Results

The ICC test gives an idea about the stability of the measurements over time on repeated trials, and whether enough range of scores is found to enable discrimination between individuals. The reliability coefficients of the variables for single measures are shown in table 2.

Variable	**Intra-Observer reliability coefficients**	**Inter-Observer reliability coefficients**
Co.Ang	**0.986**	**0.707**
Notch.an	**0.999**	**0.991**
T:M	**0.885**	**0.878**

Table 2: Intra- and inter-observer Reliability coefficients of three variables.

An initial Logistic Regression model was created. Both angles (Co.Ang, Notch.An) were found to be significant ($p < 0.05$) while T:M was not significant as sex predictor ($p > .05$) as presented in table 3.

Variable	**Significance**
Co.Ang	0.019
Notch.An	0.001
T:M	0.779

Table 3 : Statistical Significance (p value) of the three variables in the initial logistic regression model

To develop a minimally adequate model several combinations of predictors were tried. Including an interaction term rendered the model non-significant, so the final model included only the main effects of Co.Ang and Notch.An. The final model was used to create an equation. Diagnostic statistics were generated for the final model. These tested for outliers, overly influential scores and the assumption of the linearity of the logit. As a result of this process one score was deleted from the model due to a high likelihood that it was biasing the outcome.

For standardization purposes the predicted probability of being male was calculated using the following formula:

$$\mathrm{P\ (M)} = \frac{1}{1 + 2.7128\text{^} - (-47.710 + \mathrm{Co.Ang} * 0.275 + \mathrm{Notch.An} * 0.230)}$$

Where: P(M) is the probability of being male, Co.Ang is the condylar angle and Notch.An is the mandibular notch angle. The formula gives an probability of being male between 0 and 1. Subjects with a probability of > 0.5 are classified as males while subjects with a probability of < 0.5 are classified as females.

Table 4 summarizes the accuracy of the final model in sex prediction within our sample.

	Predicted		
	Sex		**Percentage Correct**
	Female	**Male**	
Female	18	6	75.0
Male	5	20	80.0
Overall Percentage			77.6

Table 4: Prediction Accuracy of the developed model

Using Microsoft Excel 16, a sex calculator was created based on the sample data. When typing the values of the 2 variables (Co.Ang and Notch.An), the probability of being male will be calculated automatically based on the previously mentioned formula. If the probability is >50% the calculator will classify the subject as MALE. . This calculator has been made available for public use and can be downloaded at this link: https://drive.google.com/open?id=1WuH2d6r8CmzGK47COOqBTWgmNnMCEEmY

To assess the validity and applicability of the sex calculator, 10 OPGs of Jordanian subjects aged between 21 and 45 years old distributed equally among sexes were analyzed. 80% of the subjects were sexed correctly.

DISCUSSION

The minimum age of the sample was adopted because of the growth of the condylar cartilages that ceases by the age of 21 years [23,24]. The age-related bone loss in the mandible starts from the age of 50 years so the maximum age of the range was 45 years old [25]. Also, there is more availability of radiographs within this age range. Furthermore, this age range follows *Krogman's* statement that sex estimation should be limited to the age range of 20-55 years [26]. More variations in the results might be observed from subjects below or above this age range.

Linear measurements were not included as the radiographs were uncalibrated and angular measurements and ratios give more precise results because they overcome the magnification errors [2,27]. Most of published studies on sex estimation of the mandible used linear and areal measurements which require analyzing calibrated or scaled radiographs [11,28,12,2,29,10]. Moreover, poor number of publications analyzed angular measurements being the gonial angle the most analyzed angle [28,30,31].

In the present study, the greatest sexual dimorphism was demonstrated by the mandibular notch angle. The value of this angle derives from four previously tested predictor variables: the head of the condyle, the head of the coronoid process, the depth of the notch and the condyle-coronoid distance [32,33,10,31]. This angle could quantify the changes of these factors and aid sexing the mandible to overcome the need for calibrating ragiographs.

The condylar angle was less statistically significant than the notch angle due to greater variability in the relationship between condylar angle and sex. The condylar head and the position of the gonion are variables affecting the value of this angle. Gonial area holds a degree of sexual dimorphism and tends to be more rounded in females and more robust in males which affects the position of Gonion [34].Again, the size and volume of the condylar head may have an effect on the condylar angle. For instance, males condyles tend to be larger which affects the posterior tangent of the ramus and subsequently widens the condylar angle [32,35,36].

Other factors that might influence the shape and size of the mandibular landmarks is the masticatory complex which is affected by testesteron hormone [37,38]. Generally speaking, as males have stronger muscles which load the mandible with greater mechanical forces, they tend to have larger mandibles [38]. Among mandibular landmarks, the coronoid process and the gonion showed more adaptation to changes in the masticatory forces [39].

The condylar angle presented lower inter observer reliability compared to mandibular notch angle. This can be explained by the number of steps required to trace gonion and measure the angle. This also likely explains the lower statistical significance of this predictor.

The triangular area consisted of the condylar height, the coronoid height and the condyle-coronoid distance. All these were found to be effective as sex-specific markers in previous studies carried out on different populations such as Indians and Brazilians with accuracies ranged from 58-96% [12,33,31,30]. The second area was formed by four parameters; condylar breadth, bigonial breadth and right and left condylar heights tested in previous studies and presented statistical significance with sexing accuracy of 68-96% [30,31,40,41]. In this study, the ratio between the two areas are statistically insignificant. Further studies can test the significance of the areal measurements separately using calibrated radiographs.

The findings of this study support the argument that angular parameters are more reliable predictors of sex on OPGs compared to horizontal measurements due to the variations in magnifications at different depths [42,43].

Our final model sexed 77.6% of the sample correctly, and we were able to correctly classify 80% of our validation sample. This finding lies within the overall accuracy range of 70-94% reported by previous studies for sex estimation using the mandible alone [2]. This high level of prediction is promising as even complete pelvis which is the best skeletal sex predictor cannot provide an accuracy rate more than 95% [26]. This finding supports the conclusion of previous studies that the mandibular ramus presents a high usefulness in sexing the mandible [44,33]. It was also argued that locations of bone remodeling in the mandible, namely the condyle and the ramus are more prone to be sexually dimorphic [33]. The prediction of male sex exhibited slightly more accuracy than female sex (80% and 75%, respectively). This can be explained by the nature of secondary sex characteristics [45]. The accuracy of this study is also superior to the results of studies conducted on the same population which showed accuracy of 67.8-70.9%. Moreover, it overcame the limitations of these studies which include analyzing calibrated radiographs and sexing the mandible morphologically [46,11].

The developed calculator could be used by forensic dentists, forensic anthropologists on living and dead subjects. It can also be used by archeologists if the ramus was intact. Indeed, it is argued that the anterior portion of the mandible is more preserved compared to the posterior portions [47].

A limitation of this study is that intact skull is required for angular measurements and according to the weak points of the mandible, the condylar neck followed be the angular component are more prone for fracture [2,48]. Nonetheless, the angular indicators in this study can be measured even on fragmented mandible if the ramus is intact specially that it is easily identified in fragmented remains [6].

Further studies should be carried out on dry mandibles and different radiographs such as lateral cephalogram. Also, the sex calculator should be tested on different populations and wider age ranges.

CONCLUSION

In conclusion, this suggested methodology presents the potential of the mandibular notch and condylar angles to sex Jordanian subjects which subsequently aids human identification and helps creating the biological profile.

Moreover, the developed sex calculator can be used by Forensic Odontologists, Forensic Anthropologists and archeologists by analyzing uncalibrated OPGs. It needs to be validated by further studies on a larger sample with wider age range, dry specimens, different radiographs and other populations.

ACKNOWLEDGEMENTS

Special thanks to **Dr. Khaled Allouh** “the manager of Isteshary Radiology center” for his cooperation and collecting the research sample.

FUNDING RESOURCES

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

COMPETING INTERESTS

The authors declare no conflict of interest.

REFERENCES

[1] Silva, R. F., Rodrigues, L. G., Picoli, F. F., Bueno, J. M., Franco, R. P., & Franco, A., Morphological analysis of frontal sinuses registered in an occlusal film by intraoral radiographic device – a case report, Journal of Forensic Radiology and Imaging (2019) 1-4. https://doi.org/10.1016/j.jofri.2019.03.001.

[2] Naikmasur, V. G., Shrivastava, R., & Mutalik, S., Determination of sex in South Indians and immigrant Tibetans from cephalometric analysis and discriminant functions, Forensic Science International 197 (2010) 122.e1–122.e6. https://doi.org/10.1016/j.forsciint.2009.12.052.

[3] International Organization for Migration, tracking deaths along migratory routes. https://missingmigrants.iom.int/region, 2019 (accessed 22 June 2019).

[4] Rosenblatt, A., International forensic investigations and human rights of the dead, John Hopkins University Press (2010) 921-950. *https://doi.org/10.1353/hrq.2010.0015*

[5] Sassouni, I., Dentofacial radiology in Forensic Dentistry, Dental Research Supplement (2015) 274-302. https://doi.org/10.1177/00220345630420012901.

[6] Black, S., & Ferguson, E., Forensic Anthropology, CRC press, New York, 2010.

[7] Deshmukh, A., & Devershi, D., Comparison of cranial sex determination by univariate and multivariate analysis, J.Anat.Soc (2006) 48-51.

[8] Hunter, J., Roberts, C., & Martin, A., Studies in Crime: An Introduction to Forensic Archaeology, Batsford, London, 1996.

[9] İşcan, M. Y., & Helmer, R. P., Forensic Analysis of the Skull, Wiley-Liss, New York, 1993.

[10] Alias, A., Ibrahim, A. N., Bakar, S. N., Rokhani, F., Shafie, M. S., & Nor, F. M., Morphometric analysis of coronoid process of mandible by CT in the Malaysian population, Journal of Dental Sciences Research and Therapy (2018) 46-53. https://doi.org/10.29199/2637-7055/DSRT.101015.

[11] Amin, W. & Othmana, D, Gender dimorphism of crania in young Jordanian adults: discriminant function analysis approach for gender prediction, Journal of Current Surgery (2014) 76-85. https://doi.org/10.14740/jcs241w.

[12] Sairam, Geethamalika, Kumar, Naresh, & Raju., Determination of sexual dimorphism in humans by measurements of mandible on digital panoramic radiograph, Contemporary Clinical Dentistry (2016) 434-439. 10.4103/0976-237X.194110.

[13] el Deeb, M., Waite, S., & Keenan, K., Standardized panoramic radiography in assessment of mandibular augmentation with hydroxylapatite material: preliminary report, J Oral Maxillofac Surg (1989) 724-729. 10.1016/s0278-2391(89)80014-x.

[14] Abdi, A. H., Kasaei, S., & Mehdizadehb, M., Automatic segmentation of mandible in panoramic x-ray, J Med Imaging (2015) 044003-1 – 044003-8. 10.1117/1.JMI.2.4.044003.

[15] Schulze, R., Krummenauer, F., Schalldach, F., & d'Hoedt, B., Precision and accuracy of measurements in digital panoramic radiography, Dentomaxillofacial Radiology (1999) 52-56. 10.1038/sj/dmfr/4600500.

[16] Jordan Government, Jordan. https://jordan.gov.jo/wps/portal/Home/search/#/searchResults?q=%D8%A7%D9%84%D8%A7%D8%B1%D8%AF%D9%86, 2016 (accessed 28 July 2019).

[17] The Jordan Press Foundation, J., Rise in crime rate registered over five-year period. http://www.jordantimes.com/news/local/rise-crime-rate-registered-over-five-year-period , 2014 (accessed 23 June 2019).

[18] Roya. , Black Thursday. https://royanews.tv/news/167567, 2018 (accessed 28 June 2019).

[19] The Jordan Press Foundation, J., Jordan tops list of refugee-host countries — Amnesty. http://jordantimes.com/news/local/jordan-tops-list-refugee-host-countries-—-amnesty, 2016 (accessed 23 June 2019).

[20] Idris, I. (2019), Serious and organized crime in Jordan. K4D Helpdesk Report 537. Brighton, UK: Institute of Development Studies

[21] Alrai Press, ارتفاع معدلات الجريمة يهدد الاستقرار الاجتماعي. http://alrai.com/article/625913.html, 2014 (accessed 29 July 2019).

[22] Schneider, C. A., Rasband, W. S., & Eliceiri, K. W. (2012), NIH Image to ImageJ: 25 years of image analysis, Nature methods 9(7): 671-675, PMID 22930834

[23] Scheuer, L. & Black, S., Development Juvenile Osteology, Elsevier, San Diego, 2000.

[24] Blackwood, H. J., Vascularization of the condylar cartilage of the human mandible, J Anat (1965) 551-563.

[25] Wowern, V., & Stoltze, K., Pattern of age related bone loss in mandibles, Scand J Dent Res (1980) 134-146. 10.1111/j.1600-0722.1980.tb01205.x.

[26] Krogman, W., the human skeleton in forensic medicine, Charles Thomas, Springfield, 1962.

[27] Hsiao, T.-H., Chang, H.-P., & Liu, K.-M., Sex determination by discriminant function analysis of lateral radiographic cephalometry, J Forensic Sci (1996) 155-160. 10.1007/s00414-009-0412-1.

[28] Kallalli, B. N., Rawson, K., Ramaswamy, V. K., Zakarneh, W. H., Singh, A., & Zingade, J., Sex determination of human mandible using metrical parameters by computed tomography: A prospective radiographic short study, Journal of Indian Academy of Oral Medicine & Radiology (2016) 7-10. 10.4103/0972-1363.189990.

[29] Suragimath, G., Ashwinirani, S. R., Christopher, V., Bijjargi, S., Pawar, R., & Nayak, A., Gender determination by radiographic analysis of mental foramen in the Maharashtra population of India, Journal of Forensic Dental Sciences (2016) 176. 10.4103/0975-1475.195114.

[30] Datta, A., Siddappa, S. C., Gowda, V. K., Channabasappa, S. R., Shivalingappa, S. B., & Srijith6, D. D., A study of sex determination from human mandible using various morphometrical parameters, Indian Journal of Forensic and Community Medicine (2015) 158-166.

[31] Lopez-Capp, T., Rynn, C., Wilkinson, C., de Paiva, L., Michel-Crosato, E., & Biazevic, M., Discriminant analysis of mandibular measurements for the estimation of sex in a modern Brazilian sample, Int J Legal Med (2017) 843-851. 10.1007/s00414-017-1681-8.

[32] Coogan, J. S., Kim, D.-G., Bredbenner, T. L., & Nicolella, D. P., Determination of sex differences of human cadaveric mandibular condyles using statistical shape and trait modeling, Bone (2017) 35-41. 10.1016/j.bone.2017.10.003.

[33] Humphrey, L. T., Dean, M. C., & Stringer, C. B., Morphological variation in great ape and modern human, Journal of Anatomy (1999) 491-513. 10.1046/j.1469-7580.1999.19540491.x.

[34] Whittaker, D., & MacDonald, D., A Colour Atlas of Forensic Dentistry, Wolfe Medical Publications, Ipswich, 1989.

[35] Kjellstrom, A., Evaluations of sex assessment using weighted traits on incomplete skeletal remains, International Journal of Osteoarchaeology (2004) 360-373. **https://doi.org/10.1002/oa.720**.

[36] Al-koshab, M., Nambiar, P., & John, J., Assessment of condyle and glenoid Fossa morphology using CBCT in south-east Asians. PLoS ONE (2015) e0121682. 10.1371/journal.pone.0121682

[37] lez-Jose´, R. G., Ramı´rez-Rozzi, F., Sardi, M., Martı´nez-Abadı´as, N., ndez, M. H., & Pucciarelli, H. M., Functional-cranial approach to the influence of economic strategy on skull morphology, American Journal of Physical Anthropology (2005) 757-771. 10.1002/ajpa.20161.

[38] Mays, S., The Archeology of Human Bones, second ed., Routledge,Abingdon, 1998.

[39] Deana, N. F., & Alves, N., Nonmetrical sexual dimorphism in mandibles of Brazilian individuals, International Journal of Medical Sciences (2017) 4233-4238.

[40] More, C. B., Vijayvargiya, R., & Saha, N., Morphometric analysis of mandibular ramus for sex determination on digital orthopantomogram, J Forensic Dent Sci (2017) 1-5. 10.4103/jfo.jfds_25_15.

[41] Saini, V., Srivastava, R., Rai, R. K., & Shamal, S. N., Mandibular ramus: an idicator for sex in fragmentary mandible, Journal of Forensic Sciences (2010) 13-16. 10.1111/j.1556-4029.2010.01599.x.

[42] Gupta, S., & Jain, S., Orthopantomographic analysis for assessment of mandibular asymmetry, J ind orthod Soc (2012) 33-37. 10.1177/0974909820120105.

[43] Kumar, S. S., Thailavathy, V., Srinivasan, D., Loganathan, D., & Yamini, J., Comparison of orthopantomogram and lateral cephalogram for mandibular measurements, J Pharm Bioall Sci (2017) S92-S95. 10.4103/jpbs.JPBS_98_17.

[44] Indira, A. P., Markande, A., & David, M. P., Mandibular ramus: An indicator for sex determination - A digital radiographic study, J Forensic Dent Sci (2012) 58-62. 10.4103/0975-1475.109885.

[45] Weiss, K. M., On the systematic bias in skeletal sexing, Am J Phys Anthrop (1972) 239-249. 10.1002/ajpa.1330370208.

[46] Badran, D. H., Othman, D. A., Thnaibat, H. W., & Amin, W. M., Predictive accuracy of mandibular ramus flexure as a morphologic indicator of sex dimorphism in Jordanians, Int. J. Morphol (2015) 1248-1254. 10.4067/S0717-95022015000400009.

[47] Symes, Schmidt, C., & S.A., The analysis of burned human remains, first ed., Elsevier, US,2008.

[48] Halazoneti, J. A., The weak regions of the mandible, British Journal of Oral Surgery (1968) 37-48. 10.1016/S0007-117X(68)80025-3.